First Clinical Experience with Excimer Assisted High Flow Bypass Surgery of the Brain

C. A. F. Tulleken¹ and R. M. Verdaasdonk²

Department of ¹Neurosurgery and ²Medical Laser Centre, University Hospital, Utrecht, The Netherlands

Summary
A new type of revascularization of the brain is used in patients with brain ischaemia, caused by an occlusion of one or both internal carotid arteries, and in patients in whom the internal carotid artery has been deliberately occluded for the treatment of a giant aneurysm of the internal carotid artery.

A so-called high flow extra-intracranial bypass operation is performed. An arterial or venous transplant is interposed between a branch of the external carotid artery or the external carotid artery itself and the intracranial portion of the internal carotid artery. The anastomosis with the intracranial portion of the internal carotid artery is made without temporary occlusion of the recipient artery and with the aid of the newly developed Excimer laser assisted anastomosis technique.

The results of animal experiments and of a clinical series of 9 patients are reported.

Keywords: High flow extra-intracranial bypass; brain ischaemia; giant aneurysm; excimer laser assisted anastomosis.

Introduction
The extra-intracranial bypass study [1] proved that the conventional extra-intracranial bypass, made between a branch of the superficial temporal artery and a branch of the middle cerebral artery, was ineffective in preventing new ischemic episodes in patients with an occlusion or a severe stenosis of the internal carotid artery or the middle cerebral artery.

One possible explanation for this result is the insufficiency of the revascularization procedure. A small donor artery and a small recipient artery, both with a diameter of less than 2 mm, were utilized, which resulted in a so-called ‘low flow’ bypass.

Hillen [2], testing the conventional bypass in his mathematical model of the Circle of Willis, proved that the minimal diameter of the bypass had to exceed 2 mm (in the case of an occluded internal carotid artery), otherwise no increase in cerebral blood flow in the effected hemisphere could be expected to result from the operation. Moreover, a proximal location of the anastomosis (preferably the intracranial portion of the internal carotid artery) is mandatory for an optimal effect of revascularization.

An anastomosis with a more proximal artery of the brain (stem of middle cerebral artery or the intracranial portion of the internal carotid artery) is technically feasible; however, there is a danger in occluding that artery during the creation of the anastomosis, because of the risk of brain ischaemia.

We developed a new anastomosis technique where donor and recipient artery are connected without occlusion of the recipient artery to allow a safe anastomosis with a proximal artery of the brain.

After initial experiments, in which the anastomosis was created mechanically [4] and with the aid of the Neodymium YAG-laser [3], we finally arrived at a rather reliable and very safe anastomosis technique utilizing the Excimer laser (Technolas, Munich) [5].

Technique
The technique of the laser-assisted anastomosis is essentially the same as that described in a previous article [3] except that the Excimer laser was used instead of an Nd: YAG laser and neither the adventitial layer nor the medial layer needs to be removed at the anastomosis site.

The technique is summarized in Fig. 1. Briefly, the end of the donor vessel is connected using approximately 12 9-0 or 10-0 interrupted sutures around its entire circumference with the exterior of the recipient artery.

An artificial side branch (a piece of vein with a diameter of about 3 mm) is created about 2 cm proximal to the anastomosis site.
in the donor artery, utilizing a conventional end-to-side technique. The tip of the Excimer laser (diameter 2.2 mm), consisting of a bundle of 140 fibres with a diameter of 100 µm (Fig. 2), is introduced via the artificial side branch and advanced until the tip touches and slightly dents the wall of the recipient artery. The tip of the Excimer laser penetrates the wall of the recipient artery in 1 to 2 sec by delivering 20-40 laser pulses of 120 nsec with an energy of 25-30 mJ at 20 Hz. When the tip of the laser catheter enters the lumen of the recipient artery, the surgeon stops pressing the foot-switch and withdraws the catheter. The side branch is immediately occluded with a haemoclip, which should be applied as proximally as possible on the side branch to prevent thrombus formation in a residual lumen.

**Experimental Study**

In 30 rabbits an Excimer assisted anastomosis was made between the common carotid arteries. A 90% patency was obtained and scanning electron microscopic examination showed the anastomosis site to be nicely endothelialized, as early as two weeks after the procedure (Fig. 2).

In a recent series of 30 rabbits we performed acute experiments, where an anastomosis was made with the aorta as the recipient artery. A less satisfactory patency rate of 70% was obtained in the subacute stage, i.e., 2–3 h after the creation of the anastomosis. To date no chronic experiments with this aorta-centered anastomosis have been performed, because of logistic reasons.

In a very recent series of experiments in 10 rabbits we performed the anastomosis with the aorta using a newly developed Excimer laser tip. This tip, with a lumen and a specially designed suction device in the tip, created perfect holes in the wall of the aorta. In the series of experiments currently underway also including chronic experiments, a much higher patency rate of the anastomoses can be expected.

**Clinical Study**

In the last year we applied the Excimer laser assisted anastomosis technique in 9 patients.

**Indications**

- 4 × a giant aneurysm of the proximal internal carotid artery intracranially, when an occlusion of the internal carotid artery in the neck was planned.
- 1 × in a patient with a carotico-cavernous fistula, in whom an occlusion of the internal carotid artery (ICA) was also planned proximally and distally from the fistula.
- 4 × in patients with an occlusion or severe stenosis of one (1 ×) or both (3 ×) internal carotid